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Briefing Report to the Chairman, Subcommittee on Environment, Energy, and Natural Resources, Committee on Government Operations, House of Representatives

February 1987

HAZARDOUS WASTE

Uncertainties of Existing Data

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United States
General Accounting Office
Washington, D.C. 20548

Program Evaluation and
Methodology Division
B-223825

February 18, 1987

The Honorable Mike Synar, Chairman
Subcommittee on Environment, Energy,
and Natural Resources
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

In your February 25, 1986, letter, you asked that we synthesize information that would answer questions you have concerning hazardous waste management and disposal. The focus of these questions is on whether the nation has sufficient capacity to manage the volume of hazardous waste being produced now and projected for the future. In responding to your request, we have found that we cannot answer these extremely important questions because of inadequacies in the national data base (see, for example, tables 2 and 3 in the accompanying briefing report). Further, we have concluded that these inadequacies severely constrain the planning and management of future hazardous waste production.

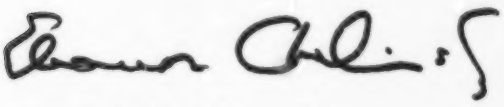
To address your request, we first systematically collected published studies relevant to the topic. We searched the literature to identify published studies that are relevant to the study questions and sought information from hazardous-waste experts in the private and public sectors. We also examined records of congressional hearings on hazardous waste to determine what, if any, volume or capacity estimates were cited when key legislative and regulatory actions were taken. Next, we analyzed and compared data across the studies. Consistent with your request, our analysis focused on studies that contain estimates of the volume and treatment, storage, and disposal capacities of hazardous waste at the national level.

After reviewing approximately 90 studies and documents, we found significant data gaps, methodological problems, and other issues that prohibit us from (1) relying upon available information to provide estimates of the total volume of hazardous waste and (2) determining whether future treatment, storage, and disposal capacity will be quantitatively adequate to meet the volume of hazardous waste generated. We conclude that a variety of uncertainties complicate answering the questions you posed. The amount of hazardous waste that will be produced from

Superfund sites and the effects of the various requirements of the Hazardous and Solid Waste Amendments of 1984 are only two of these uncertainties.

As we agreed with your office, unless you publicly announce the contents of this report earlier, we plan no further distribution of it until 30 days from the date of the report. At that time, we will send copies to those who are interested and will make copies available to others upon request. In addition, in accordance with the wishes of the subcommittee, we did not ask EPA to comment on a draft of this report. Copies will be available to those who request them. For further information, please contact Carl Wisler on (202) 275-3092.

Sincerely yours,



Eleanor Chelimsky
Director

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Abbreviations

CBO	Congressional Budget Office
EPA	Environmental Protection Agency
GAO	General Accounting Office
NAS	National Academy of Sciences
OTA	Office of Technology Assessment
RCRA	Resource Conservation and Recovery Act of 1976

Introduction

Over the last decade, there has been growing concern about the volume of hazardous waste being generated and its adverse effects on public health and the environment. This concern has resulted in the passage of legislation directed at ensuring the management of hazardous waste. The Environmental Protection Agency (EPA) has primary responsibility for implementing programs authorized by this legislation. As an integral part of the national program to manage hazardous waste, many studies have been conducted to develop important relevant information. It is important that such basic information as the amount and type of hazardous waste generated, where it is generated, and how it is treated, stored, or disposed of be adequate and available to the Congress in order that meaningful national policy can be formulated on a major national issue.

Background

Hazardous waste, if not properly managed, may lead to insults to the public health and the environment and, eventually, the need for costly cleanup measures. To ensure appropriate hazardous waste management, the Congress mandated a hazardous waste regulatory program under the Resource Conservation and Recovery Act of 1976 (commonly called "RCRA"). The act established guidelines for the management of hazardous waste from its initial generation to final disposal. In implementing this and subsequent legislation, EPA developed a general definition of hazardous waste that includes substances that are ignitable, corrosive, reactive, or toxic. EPA presently lists over 400 specific substances as hazardous.

The Congress also enacted the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (widely known as "Superfund") to address the problem of abandoned hazardous waste sites. This act specifically requires the cleanup of hazardous waste that was generated in the past and has been abandoned or left uncontrolled. Over the last few years, the number of sites identified as requiring cleanup has increased, although the total that will eventually have to be cleaned up and the amount of hazardous waste requiring disposal from them are uncertain.

The 1976 and 1980 acts in themselves did not stimulate efforts by generators of waste to engage in waste-reduction activities or to reduce their dependence on potentially ineffective land-disposal practices. Similarly, EPA regulations promulgated in 1980 did not discourage ineffective land-disposal practices. In response to this concern, the Congress passed

major revisions to the 1980 act in 1984, calling the revisions the Hazardous and Solid Waste Amendments Act. The amendments were designed to modify previous exemptions for firms that produce small quantities of hazardous waste, to promote more widespread recycling of hazardous waste, and to reduce unsound land-disposal practices.

EPA is responsible for implementing all three acts. Under the 1976 act and the 1986 amendments, EPA is responsible for (1) establishing hazardous waste programs in each state; (2) developing regulations for the management of hazardous waste, including its generation and disposal; and (3) reporting biennially to the Congress on the status of the nation's hazardous waste program, including the number of generators of hazardous waste. Under the 1980 act, EPA's efforts are directed toward identifying and cleaning up abandoned hazardous waste sites.

Current Concerns

Increased national concerns about health and safety have resulted in the need for comprehensive information describing the nature and extent of the problem of hazardous waste. The concerns being raised include those relating to the amount of hazardous waste being generated; the present and future quantitative adequacy of treatment, storage, and disposal capacities; the effect that increasing amounts of Superfund wastes will have on available treatment, storage, and disposal capacities, and the effect of recent legislation on future generation and capacity. Some of these issues have already been studied but questions remain. Prior to 1980, only a few, limited studies developed estimates of the amount of hazardous waste generated nationally. More recently, the number of studies has increased, but most of them provided estimates for only a sector, such as a limited geographic area or a particular waste type. A few studies have provided estimates for the total amount of hazardous waste produced nationally since the passage of the Resource Conservation and Recovery Act.

In response to the growing concerns about the hazardous waste issue, the Honorable Mike Synar, Chairman of the Subcommittee on Environment, Energy, and Natural Resources of the Committee on Government Operations, asked us to address the issue of whether future treatment, storage, and disposal capacities will be quantitatively adequate to manage the volume of wastes being generated. To address this question, more detailed questions had to be answered. We present these questions and our evaluation approach in the section below.

Objectives, Scope, and Methodology

In his February 25, 1986, letter (reprinted here in appendix I), Chairman Synar expressed concern about whether the nation has adequate treatment, storage, and disposal capacities to deal with the increasing volume of hazardous waste being produced. He asked us to synthesize existing information concerning the volume of hazardous waste being generated and treated, stored, and disposed of. The synthesis was also to identify major methodological problems that may lead to misestimates of either volume or capacity. Specifically, the chairman asked us to answer the following four evaluation questions:[1]

1. What are the amount, location, and source of known and expected hazardous waste?

2. What are current treatment, storage, and disposal capacities and what is projected for the future to manage and dispose of hazardous waste?

3. How have estimates of volume and capacity changed since the enactment of the Resource Conservation and Recovery Act in October 1976?

4. What uncertainties and data gaps obscure the answers to the foregoing questions and what methodological problems should be addressed in order to provide better information?

The objectives of our study were to identify and analyze existing information from studies and other documents and, if possible, to synthesize this information into meaningful answers to the evaluation questions.

We established the scope of our study to reflect both the type of information requested and the time in which the information had to be obtained. Recognizing that hazardous waste is controlled under various federal and state programs, we did not attempt to limit our universe of studies and documents to only one specific definition of hazardous waste. Rather, we considered studies on all types of hazardous waste, including waste from Superfund sites.

We focused on reports and documents that contained information on national estimates of the volume and capacity of hazardous waste. We identified two groups: national and national-sectoral studies. The first provided estimates on total hazardous waste generated or processed

[1]These questions have been revised slightly from those of the original congressional request. The revisions were made for clarity.

nationally. The second furnished national estimates for a specific source or type of hazardous waste or provided information for a specific geographic area.

As mentioned earlier, the methodology for the evaluation was the information synthesis. An information synthesis includes two major activities: identifying the major information references that provide the base for the synthesis and reviewing the references in order to acquire information that will answer the study questions and identify methodological problems within the information base.

Our first step was to identify and collect all pertinent studies and documents within the scope of our study. We identified references on estimates of volume and management capacity from literature searches of standard computerized bibliographic files and specialized technical literature files. We reviewed the legislative histories and searched specialized files to identify references to congressional hearings, records, and testimony. We identified additional references by reviewing bibliographies of our previous reports on hazardous waste and a Congressional Research Service information package on the topic. Once we identified an initial list of references, we obtained the studies and documents and reviewed their bibliographies for additional references, which we also obtained.

To ensure that we had identified the major studies and documents, we contacted program officials at the Environmental Protection Agency, the Congressional Research Service, the Office of Technology Assessment (OTA), the Congressional Budget Office (CBO), and the National Academy of Sciences (NAS) as well as other experts, hazardous-waste consultants, and a representative of a hazardous waste treatment trade association. We asked them to verify our list. We also contacted and obtained additional information from various state officials. In all, we obtained and reviewed approximately 90 studies and documents, listed in the bibliography.

As we reviewed these studies and documents, we were impressed with the vastly different definitions of hazardous waste being used and the overall lack of precision of data supporting the estimates. A number of the authors had cautioned that because of various limitations, their estimates could not be directly compared with estimates from other studies. They had also noted data gaps, problems in measurement, and other sources of error. Discussions with experts reinforced our conclusion that

the information could not be synthesized into meaningful national estimates.

Recognizing the inadequacy of the information base for an information synthesis, we documented its condition as we reviewed the studies and documents. We did, however, conduct two principal parts of an information synthesis, identifying the universe of relevant studies and conducting a methodological evaluation. To ensure consistent documentation, we developed and used a standardized format to extract information from the references. Data elements included the scope of a study; its definition of waste and estimates, methodology, and data gaps; and uncertainties noted by the authors.

Our analysis, as documented within this briefing report, is a comparison and contrast of the major national studies. The sequence of the remaining sections in this report follows the order of the evaluation questions and provides information on our findings on each one. The final section contains our conclusions.

In accordance with the wishes of the chairman's office, we did not ask EPA to comment on a draft of this report.

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Known and Expected Hazardous Waste

A number of studies have developed estimates of the amount of hazardous waste produced nationally since the enactment of the Resource Conservation and Recovery Act in 1976. However, the published estimates vary significantly (from 9 to 266 million metric tons), and the most current data are inconsistent from one study to the next for specific time periods. To illustrate this, we have provided the national estimates from four studies for 1981 through 1984 in table 1.

Table 1: National Hazardous Waste Studies With Similar Estimates 1981-84

Source	Year of measurement	Point estimate[a]	Interval estimate[a]	Approach
Chemical Manufacturers Association[b]	1984	247	Not estimated	Survey of association members
CBO[c]	1983	266	223–308[d]	Modeling estimate developed from disaggregated industry data
EPA-Westat[e]	1981	264	135–402[d]	Statistical sample of generators and treatment, storage, and disposal facilities
OTA[f]	1981	Not available	255–75[g]	Compilation of data reported from states

[a]Million metric tons.

[b]Chemical Manufacturers Association and Engineering Science, Inc., Results of the 1984 CMA Hazardous Waste Survey (Austin, Texas: January 1986).

[c]Congressional Budget Office, Hazardous Waste Management: Recent Changes and Policy Alternatives (Washington, D.C.: May 1985).

[d]Confidence interval.

[e]U.S. Environmental Protection Agency, National Survey of Hazardous Waste Generators and Treatment Storage and Disposal Facilities Regulated Under RCRA in 1981 (Washington, D.C.: April 1984).

[f]Office of Technology Assessment, Technologies and Management Strategies for Hazardous Waste Control (Washington, D.C.: March 1983).

[g]An upper and lower range.

The point estimates in three of these studies are quite close together, and the mean of the three estimates is about 260 million metric tons. But the coincidence of the point estimates may be misleading. Indeed, we noted a number of disparities and limitations associated with the methodologies that belie the similarity of these estimates.

The point estimate prepared by the Chemical Manufacturers Association, 247 million metric tons for 1984, is seemingly close to the other point estimates, but it represents only a portion of the total chemical industry. Further, the chemical industry is only a subsector of the total

hazardous waste generation sector (estimates we reviewed of the chemical industry's contribution to total waste volume ranged from 48 percent to 68 percent). Consequently, we conclude that the estimate from the Chemical Manufacturers Association accounts for only part of the hazardous waste generated each year and that an extrapolated estimate for the remainder of the chemical industry and for the nation could be significantly greater.

The second point estimate, prepared for EPA by Westat in 1981, is 264 million metric tons. The range provided in the study, 135 to 402 million metric tons, is a statistical confidence interval, and the authors stated that they are 95-percent confident that the true 1981 hazardous waste production level falls within this interval.

However, this confidence interval is so very wide (267 million metric tons, which is equal to a range of about plus or minus 50 percent), that the credibility of the estimate is limited. In searching for an explanation of this considerable imprecision, we found that the study focused on waste generators and treatment, storage, and disposal facilities regulated under RCRA, the 1976 act. The sampling scheme was designed to provide accurate data on the characteristics of the technology of the facilities rather than to measure the amount of hazardous waste generated. The populations of generators and facilities regulated under the act were found to be highly skewed in terms of size—so skewed, in fact, that nearly all the totals of the hazardous waste generated and managed were accounted for by very small proportions of their respective populations. Inadvertently, the sample was not designed for a skewed population, and this resulted in estimates containing the high degree of sampling error that we have noted.

The third point estimate, prepared by the Congressional Budget Office, is similar to that prepared by Westat for EPA (a point estimate of 266 million metric tons, for 1983). The confidence interval around the CBO point estimate is from 223 to 308 million metric tons, with a statistical confidence level of 95 percent. In this case, the confidence interval is plus or minus 16 percent, much smaller than that of the Westat study. This estimate is the product of a national hazardous-waste generation model developed by CBO under two theoretical assumptions: (1) specific industries generate characteristic wastes at measurable rates and (2) the overall quantity of waste produced is a function of industrial output (as measured by production employment), process technology, and production efficiency.

The CBO model used employment data as a key variable to produce the hazardous waste estimates. But other studies have suggested that using employment data produces estimates that substantially disagree with actual waste generation data obtained from surveys of generators. Therefore, using employment data as an independent variable in deriving estimates of hazardous waste is questionable.

The Office of Technology Assessment study took a different approach for developing its range estimate, in that it did not generate a point estimate but asked the Association of State and Territorial Solid Waste Management Officials to collect data from a survey. The results indicated that approximately 250 million metric tons of hazardous waste were being produced annually by 40 states, Guam, and Puerto Rico, with an estimated additional 5 to 25 million metric tons of waste being produced annually by the nonresponding states and territories. This worked out to a volume estimate of between 255 million and 275 million metric tons. The states' waste generation data were derived from a number of different approaches: 19 states appear to have used state inventories; 5 states appear to have used data on manifested hazardous waste, thus underestimating waste generation, unless the analysis included extrapolation to account for waste managed on-site; and data from the remaining responses were derived through the use of EPA notifications and estimates of waste generated by industrial sectors receiving the notifications. Only 9 states, plus Guam, Puerto Rico, and Washington, D.C., used a definition of hazardous waste consistent with that used by EPA at the time. Because of these within-study differences in definition and measurement, the accuracy of OTA's estimate, like that of the other studies, gives reason for some concern.

Comparing the definitions of hazardous waste used by the Westat, CBO, and OTA studies, we found them dissimilar. The Westat study estimated the quantities of hazardous waste that were generated in 1981 and subject to control under the regulations for the 1976 act. However, two categories of waste were not included in the study's definition of hazardous waste:

1. wastes that had been exempted or excluded from regulation as hazardous waste (such as those generated in conjunction with ore and minerals extraction and smelting preparation) and

2. hazardous wastes that were regulated under the 1976 act and generated in 1981 but that were not, at any point in the management process, treated, stored, or disposed of in processes subject to regulation under

the act (such as hazardous wastes treated exclusively in wastewater-treatment tanks covered under the National Pollutant Discharge Elimination System).

The CBO study used a broader definition of hazardous waste than that established by EPA under the Resource Conservation and Recovery Act of 1976. It included wastes not regulated under this act, such as waste oils, industrial chemicals such as polychlorinated biphenyls (PCBs), industrial-scrubber sludges, air-pollution-control dusts, and certain liquid hazardous-waste streams.

Since the OTA study was a survey of states, its estimate is based not only upon the federal regulatory definition but also upon the state definitions. The states sometimes defined hazardous waste differently and more broadly than the federal government, including many different types of unregulated waste such as additional chemical compounds, wastes from small-quantity generators, exempted wastes, and various solid wastes. The states' definitions varied from one state to another. Consequently, the basis for the OTA estimate is quite different from that in each of the two other studies.

All these differences signify that the estimates in the four studies must be considered separately. Although the four current, national estimates did reach similar numerical estimates of hazardous waste, it should not be assumed that they reinforce one another, given their differing qualitative bases, statistical precision, and approaches to definition and measurement. These factors indicate that a broad methodological evaluation of how best to estimate national hazardous waste volume is necessary. We are currently planning such an evaluation.

In addition to the four major studies we have just discussed, national-sectoral studies provide data and information about hazardous waste that is more narrowly scoped. We reviewed these studies to determine whether their information can be synthesized to provide national estimates. Given various technical, methodological, and other factors (to be discussed later), we believe it is not possible to synthesize national-sectoral studies in a way that can provide accurate and reliable national estimates.

Very little information is available that can be used to make accurate estimates of the volume of hazardous waste generated by location. A state-by-state comparison of the data given in the CBO and OTA studies is provided in table 2, and it is important to note that the state estimates

Table 2: Two Studies' Estimates of Hazardous Waste Volume by State in Metric Tons

State	1981 OTA[a]	1983 CBO[b]
Alabama	265,680	6,547,000
Alaska	360	52,000
Arizona	4,260,000	642,000
Arkansas	No data	3,729,000
California	15,000,000	17,284,000
Colorado	775,490	1,902,000
Connecticut	102,000	4,238,000
Delaware	272,000	894,000
Florida	No data	2,981,000
Georgia	38,500,800	3,338,000
Hawaii	No data	202,000
Idaho	No data	1,160,000
Illinois	1,810,000	14,810,000
Indiana	94,900,000	10,189,000
Iowa	No data	1,774,000
Kansas	45,300	2,564,000
Kentucky	415,000	4,647,000
Louisiana	38,800,000	13,801,000
Maine	5,290	337,000
Maryland	272,100	2,989,000
Massachusetts	172,000	4,536,000
Michigan	408,000	12,399,000
Minnesota	181,000	2,212,000
Mississippi	1,810,000	1,816,000
Missouri	658,930	6,046,000
Montana	91,200	662,000
Nebraska	1,250,000	739,000
Nevada	No data	379,000
New Hampshire	9,980	431,000

are very disparate. This is not surprising, given the basic differences already explained, but we have not yet had the opportunity to determine precisely how much of the disparity is attributable to definitions, methodology, or other features of the studies. It is clear that the disparities in the estimates preclude any conclusive statements about how much waste is being generated within each state.

State	1981 OTA[a]	1983 CBO[b]
New Jersey	855,000	12,948,000
New Mexico	No data	619,000
New York	1,270,000	9,876,000
North Carolina	No data	3,954,000
North Dakota	125,000	269,000
Ohio	3,260,000	19,692,000
Oklahoma	3,570,000	2,673,000
Oregon	19,100	969,000
Pennsylvania	3,629,000	18,260,000
Rhode Island	1,600	1,745,000
South Carolina	1,587,000	3,669,000
South Dakota	1,590	159,000
Tennessee	4,300,000	12,159,000
Texas	29,146,960	34,866,000
Utah	558,000	1,139,000
Vermont	9,070	226,000
Virginia	181,000	4,038,000
Washington	616,000	5,523,000
West Virginia	No data	5,642,000
Wisconsin	81,600	3,297,000
Wyoming	No data	572,000
Other	5–25 million[c]	•
Total	**255–75 million**	**265,595,000**

[a]Office of Technology Assessment, Technologies and Management Strategies for Hazardous Waste Control (Washington, D.C.: March 1983).

[b]Congressional Budget Office, Hazardous Waste Management: Recent Changes and Policy Alternatives (Washington, D.C.: May 1985).

[c]The actual national estimate was 250 million metric tons, but this did not include 10 states. OTA estimated that including them would result in an estimate of 255-75 million metric tons.

Other studies have attempted to provide estimates at various geographic levels. For example, studies were prepared for New England by Arthur D. Little and the New England Congressional Institute, and other data exist at the state level as well. Information for selected states is presented in table 3 to illustrate this. The variance between the studies' estimates for the states is considerable. We conclude that the studies that we reviewed do not provide consistent information concerning the volume of hazardous waste generated by location. The wide disparity in estimates indicates the need for a methodological evaluation of why the estimates are so different and how to correct the problem. We are currently planning to conduct such an evaluation.

Table 3: Five Studies' Estimates of Hazardous Waste Volume in Selected States for 1980-83 in Metric Tons

State	Arthur D. Little[a]	CBO[b]	Gould[c]	New England[d]	OTA[e]	Other
California	•	17,284,000	4,501,642	•	15,000,000	1,179,100
Connecticut	127,207	4,238,000	1,808,437	193,725	102,000	•
Illinois	•	14,810,000	5,149,737	•	1,810,000	2,503,320
Maine	8,118	337,000	180,463	10,211	5,290	•
Massachusetts	158,816	4,563,000	1,851,208	111,017	172,000	•
New Hampshire	15,646	431,000	184,543	12,410	9,980	•
Oklahoma	•	2,673,000	634,246	•	3,570,000	•
Rhode Island	34,421	1,745,000	524,369	3,989	1,600	•
Tennessee	•	12,159,000	2,588,475	•	4,300,000	644,877
Texas	•	34,866,000	6,337,588	•	29,146,960	57,125,071
Vermont	8,163	226,000	100,210	7,425	9,070	•

[a]Arthur D. Little, "Hazardous Waste Generation in New England," prepared for The New England Council, Boston, Mass., 1982, as reported in Michael R. Greenberg and Richard F. Anderson, Hazardous Waste Sites: The Credibility Gap (New Brunswick, N.J.: The Center for Policy Research, 1984), p. 23.

[b]Congressional Budget Office, Hazardous Waste Management: Recent Changes and Policy Alternatives (Washington, D.C.: May 1985).

[c]Jay M. Gould, Quality of Life in American Neighborhoods: Levels of Affluence, Toxic Waste, and Cancer Mortality in Residential Zip Code Areas (Boulder, Colo.: Westview Press, Inc., 1986).

[d]New England Congressional Institute, Hazardous Waste Generation and Management in New England (Washington, D.C.: February 1986).

[e]Office of Technology Assessment, Technologies and Management Strategies for Hazardous Waste Control (Washington, D.C.: March 1983).

National information characterizing the amount or volume of hazardous waste attributable to specific sources is similarly disparate. Two studies that attempted to delineate the contribution of different sources have been cited already, the CBO and Westat studies. In these, however, the estimated contribution of various sources varies widely. The CBO study, for example, reported the contribution of the chemical industry at 48 percent of the total hazardous waste volume produced. The Westat study estimated the contribution of the same industry to be 68 percent. The incremental difference between these two estimates can result in an estimated difference of millions of metric tons of hazardous waste, depending on the base being used. In the CBO study, the generation of waste attributed to the chemical industry is approximately 127 million metric tons; in the Westat study, it is approximately 180 million metric tons. Contrasting these estimates with that of the Chemical Manufacturers Association for 1984—247 million metric tons for only a partial sector of the total chemical industry—shows a significant variation. We found that estimates of the amount of waste contributed by different

sources vary so much that any conclusions about the relative contribution of different sources of hazardous waste should be highly qualified.

We were also asked to look at what is known about future estimates of the volume of hazardous waste. We found only one study that provided future estimates, the 1983 CBO study, which furnishes an estimate of 229 to 280 million metric tons in 1990. However, some methodological uncertainties must be noted. Using the CBO model to predict future waste volume is subject to at least two kinds of error, identified by CBO.

First, the model may have underestimated waste generation in future years because of the use of production employees as a proxy for output by industry. The CBO study used projections of employment growth by industry, obtained from the Bureau of Labor Statistics, because they were the only consistent set of industry-specific projections available. But the use of employee statistics might understate the estimate, since growth in labor productivity over time will lead to increased output and, presumably, more waste per employee.

Second, the model's projections might have overstated the amount of waste by failing to account for turnover in the facilities, equipment, or both for industries that generate waste. New industrial facilities may be more efficient and produce less waste per worker or per unit of output. Because there is no way to know which of these effects might be greater, uncertainties are associated with these estimates. CBO did not discuss other possible kinds of error such as uncertainties from forecasting employment growth.

Treatment, Storage, and Disposal Capacities

The information on present and future capacity to treat, store, and dispose of hazardous waste is more limited than the information on volume. We identified three studies that addressed, to some extent, capacity at the national level. Two studies, conducted for EPA by Booz-Allen and Hamilton with Putnam, Hayes, and Bartlett (referred to as the Booz-Allen study) and by Westat, provide such information for 1981. The third study, prepared by CBO, provides information for 1983 and 1990.

The Booz-Allen study is limited in scope in that it addressed only off-site capacity in detail (that is, the capacity of the commercial hazardous waste management industry). This study estimated that in 1981, approximately 40 million metric tons of waste were managed, 31 million metric tons on-site and 9 million metric tons off-site. In examining off-site capacity for handling the amount of waste generated in that year, the study concluded that, at the national level, there would be off-site shortfalls in capacity.

The Westat study is more extensive in scope, addressing both on-site and off-site treatment, storage, and disposal capacities. Westat estimated the volume of waste managed for 1981 to be 265 million metric tons; approximately 254 million and 11 million metric tons were managed on- and off-site, respectively. The study's conclusions were that 23 percent of total treatment capacity, 64 percent of total storage capacity, and 36 percent of total disposal capacity were used in 1981. The precision of the volume estimate in the Westat study was not very high (plus or minus 50 percent). The estimate for the amount of hazardous waste being managed was similarly imprecise (plus or minus 49 percent). In both, the imprecision was at least partly a consequence of the highly skewed population being sampled.

Although the Booz-Allen and Westat studies provided estimates for the same year, their estimates for total waste volume managed and the proportion of waste processed off-site are quite different. In addition, their methodological approaches were different. The Booz-Allen study was designed to summarize existing hazardous waste generation data and to undertake a survey of commercial hazardous waste management facilities. Booz-Allen used data bases from earlier industrial studies. Consequently, all variations and limitations in definitions and methodologies from these studies were incorporated. In addition, the data did not reflect consistent time periods or whole industry sectors. To compensate for these discrepancies, statistical adjustments were made. Finally, the Booz-Allen study (which looked only at off-site capacity) estimated that

23 percent of waste was processed off-site, while Westat (which addressed both off-site and on-site capacity) estimated this figure to be 4 percent.

The CBO study discussed earlier also provided some information on capacity. However, the information is limited, because it addressed only how the amount of waste being generated is managed by the treatment, storage, and disposal facilities, not whether there will be excess current or future capacity. The study assumed that adequate treatment, storage, and disposal capacities would be available to meet the requirements in 1983. The CBO's only position on future capacity concerned off-site capacity; the study noted that unless new off-site facilities are built by 1990, the demand could easily overwhelm capacity.

In summary, we found very little information on current and future national capacity. The one study that comprehensively addressed capacity (Westat for EPA) appears to have an important methodological limitation with regard to the degree of sampling error. EPA has recently acknowledged a data gap in estimates of waste treatment, storage, and disposal capacities. As a result, the agency is currently conducting a census of treatment, storage, and disposal facilities to obtain national data on existing capacity.

Estimates of Volume and Capacity Since 1976

Our third question required us to identify estimates of changes in volume and capacity over time and to determine the estimates that were cited when key legislative and regulatory actions were taken. The changes in national estimates of volume since 1973 can be seen in table 4. The problem with giving much attention to changes over time is that individual estimates may be accounted for as much by differences in scope, definition, and methodology as by true changes. The point estimates reported range from 9 million to 266 million metric tons over 15 years. The point estimates for 1981 alone range from 43 to 264 million metric tons, a factor of more than 6. For the period 1981 through 1984, the estimates appear to be coming closer together, but for the reasons we have given earlier, this closeness is not necessarily an indicator of accuracy.

To determine the estimates that were cited when key legislative and regulatory actions were taken, we focused on hearings, records, and testimony related to four events:

- the enactment of the Resource Conservation and Recovery Act in 1976,
- the implementation of this act's notification requirements in 1980,
- the passage of the Hazardous and Solid Waste Amendments Act in 1984, and
- the implementation in 1985 of the certification requirements under the Resource Conservation and Recovery Act.

We found that EPA did not generate estimates specifically for these events. Rather, data on hazardous waste volume—that is, estimates that were prepared over a 12-year period—were used in association with these events. With regard to capacity, we found no estimates whatever—extant or otherwise—in our review of the legislative history.

Table 4: Estimates of Hazardous Waste Volume in 1973-86 in Million Metric Tons

Year of publication	Year estimated for	Study	Waste volume[a]
1973	1970	EPA[b]	9
1977	1974	EPA[c]	29
1980	1980	EPA[d]	54
1980	1980	Booz-Allen[e]	41
1980	1981	Booz-Allen[e]	43
1983	1981	Preliminary EPA-Westat[f]	150
1983	1981	OTA[g]	255–75
1984	1981	EPA-Westat[f]	264
1985	1983	CBO[h]	266
1986	1984	Chemical Manufacturers Association[i]	247[j]
1986	1980	Gould[k]	91

[a]Most studies reported volume as million metric tons. For studies reporting volume in different units, we converted to metric tons.

[b]U.S. Environmental Protection Agency, Report to Congress: Disposal of Hazardous Wastes (Washington, D.C.: 1974).

[c]EPA as reported in Michael R. Greenberg and Richard F. Anderson, Hazardous Waste Sites: The Credibility Gap (New Brunswick, N.J.: Center for Policy Research, 1984), pp. 5-9.

[d]U.S. Environmental Protection Agency, "Hazardous Waste Management System: Identification and Listing of Hazardous Wastes," 45 Fed. Reg. 33084 (May 19, 1980).

[e]Booz, Allen and Hamilton, Inc., and Putnam, Hayes, and Bartlett, Inc., Hazardous Waste Generation and Commercial Hazardous Waste Management Capacity: An Assessment (Bethesda, Md.: November 1980).

[f]U.S. Environmental Protection Agency, National Survey of Hazardous Waste Generators and Treatment, Storage and Disposal Facilities Regulated Under RCRA in 1981 (Washington, D.C.: April 1984).

[g]Office of Technology Assessment, Technologies and Management Strategies for Hazardous Waste Control (Washington, D.C.: March 1983).

[h]Congressional Budget Office, Hazardous Waste Management: Recent Changes and Policy Alternatives (Washington, D.C.: May 1985).

[i]Chemical Manufacturers Association and Engineering-Science, Inc., Results of the 1984 CMA Hazardous Waste Survey (Austin, Texas: January 1986).

[j]This amount is for a subset of the chemical industry.

[k]Jay M. Gould, Quality of Life in American Neighborhoods: Levels of Affluence, Toxic Waste, and Cancer Mortality in Residential Zip Code Areas (Boulder, Colo.: Westview Press, Inc., 1986).

EPA estimated in a 1973 report to the Congress that 9 million metric tons of nonradioactive hazardous waste were generated by industrial sources nationally in 1970. EPA cited and used this estimate in hearings related to the enactment of RCRA in 1976 and later in appropriations hearings. During the June 29, 1976, hearings on the enabling legislation, EPA provided a range of volume estimates of 27.5 million to 41.25 million metric tons. During the 1980 implementation of the notification requirements, EPA did not develop or cite specific estimates of volume or capacity and did not report estimates using data generated by the notification process. During congressional hearings prior to the enactment of the 1984 Hazardous and Solid Waste Amendments, OTA cited an EPA estimate of 150 million metric tons, which was a volume estimate made for 1981. For the appropriations hearings after the 1984 amendments, EPA did not provide an estimate of hazardous waste volume or capacity. Finally, EPA did not report estimates in conjunction with the 1985 implementation of the certification process.

The fact that no estimates of capacity were developed with regard to these major events is symptomatic of the problem presented earlier: there is a gap in the data on the national capacity to treat, store, and dispose of hazardous waste.

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Uncertainties, Data Gaps, and Methodological Problems

Our work uncovered a number of serious problems in and across the information available about hazardous waste. We identified some of the major methodological problems that will have to be addressed if stronger information is to be developed. In our review of the existing studies of the volume of hazardous waste and the national capacity for managing it, several important categories of problem stand out:

1. variation in the scope of estimates;

2. variation in the definition of hazardous waste;

3. variation in measures for estimating the amount of waste generated or the capacity for storage, treatment, or disposal; and

4. sampling and response error.

Variation in the Scope of Estimates

Some of the studies we reviewed focused on a particular waste stream or contaminant (for example, solvent wastes) or a specific management approach (for example, incineration or land fills) or a particular industrial or source sector (for example, the petrochemical industry) or some geographic unit (for example, New England). Given the many possible variations along these dimensions, it is virtually impossible to use a collection of such studies to derive accurate national estimates by aggregating across the studies. There are too many missing classes of information, on the one hand, and too much double-counting, on the other.

We illustrate this point with two studies. One focused on hazardous-waste solvents affected by land-disposal restrictions as well as solvent waste generated by small generators of waste now covered by the 1984 amendments. The scope of this study did not include solvent wastes disposed of in salt dome formations, salt bed formations, and underground mines and caves. The other study focused exclusively on waste produced by 48 small-quantity generators.

A number of questions would have to be answered before the data contained in these two studies could be synthesized. For example, do the data on the 48 small-quantity generators include or exclude solvent wastes? Did both studies address only the small-quantity generators covered by the 1984 amendments? Often, because of limitations in how studies' universes are described, it is very difficult, if not impossible, to

answer the basic questions necessary for combining information across studies.

When the purpose of making volume and capacity estimates is for local or regional planning, or when the planning is limited along some other dimension such as the type of waste, the restricted scope of the available studies may not be a limiting factor. But when national estimates are needed for policymaking, we believe they cannot be obtained by combining multiple studies limited in scope.

Variation in the Definition of Hazardous Waste

In our review, we found that many different definitions of hazardous waste were used across studies and, in some, definitions varied within a study. We believe that these differences account for some of the uncertainty in the estimates of volume and capacity.

We have not yet formed a judgment about the net effect on estimates of the variation in definitions, but our work confirms the conclusion the Office of Technology Assessment reached in 1983: inadequate data, including the problem of differing definitions, conceal the scope and intensity of the national hazardous waste problem and hinder the effective implementation of government programs.

Variation in Measures for Estimating Volume and Capacity

The volume of hazardous waste and the capacity for dealing with it are described in various ways within and across studies, ranging from common measures such as tons, gallons, or cubic yards to more ill-defined indicators such as ponds or sites. Even when estimates are given in terms of standard measures such as gallons, there may be ambiguity because the concentration or form of hazardous material (for example, liquid or solid) may vary or not be known. For example, 100 gallons of liquid may be contaminated in a concentration of 1,000 parts per million or 10 parts per million. This difference may be important in terms of whether an appropriate technology is available to adequately manage the waste in the concentration in which it exists. Currently available estimates of the amount of hazardous waste frequently do not account for variations in concentration and form.

Sampling and Response Errors

Although estimates of volume and capacity can be made in different ways, an empirically based estimate ultimately depends upon acquiring information with appropriately designed methods. Our review of studies identified two kinds of problem: sampling errors and response errors.

Neither is irremediable or intractable. Both can be greatly reduced, if not eliminated, through careful planning and skilled instrumentation.

There are thousands of waste generators and also thousands of facilities for treating, storing, and disposing of waste. As a practical and economic matter, it is difficult to acquire detailed information about all these generators and facilities. Thus, how samples are chosen is important in determining the accuracy and precision of the national estimates of volume and capacity projected from those samples.

For example, a large degree of statistical uncertainty accompanied the 1981 Westat estimates of the volume of hazardous waste. There was a direct link between the sample chosen and the uncertainty of the estimates.

Response errors are the errors that people make in responding to questions about volume and capacity. Some of these errors are derived from the problems of definition and measurement ambiguity referred to earlier. That is, people who provide information may not correctly understand the request for data or may be unable to provide the information in the form that is asked for. Given the large number of substances that constitute hazardous waste, the many generators and facilities involved, and the relatively recent attention given to measuring volume and capacity, we believe that response errors may lead to substantial inaccuracy and imprecision in estimates of volume and capacity. Reduction in response errors will require more precise and uniform definitions of terms and greater attention to data-collection techniques that minimize errors.

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Conclusions

Will the national treatment, storage, and disposal capacities for hazardous waste be quantitatively sufficient to meet future hazardous waste management requirements? The published information does not allow us to determine whether treatment, storage, and disposal capacities will be quantitatively adequate to meet the hazardous waste volume that will be produced. In addition, several uncertainties—for example, the amount of hazardous waste that will be produced specifically from Superfund sites, the effect of the proposed ban on the land disposal of some hazardous wastes, and the requirements of the Hazardous and Solid Waste Amendments of 1984 for certification for compliance with groundwater monitoring and financial responsibility—complicate this question still further.

We have concluded that the Congress does not currently have the information base that it needs to plan appropriately for the management of hazardous waste, either now or in the future. But before the development of such an information base can be ensured, we believe that certain methodological issues have to be addressed, including the ways in which hazardous waste is defined, estimates are scoped, and studies are designed. For example, design strengths would include using a variety of approaches in which the weaknesses of some are offset by the strengths of others and using data-collection methods that tend to minimize error. We are planning to conduct evaluations in these areas.

It is true that some regional and state studies of volume exist for certain geographic areas and source categories. However, we believe that these data cannot be synthesized to provide national estimates because of the many differences from study to study. Consequently, we cannot estimate the amount, location, and source of hazardous waste being produced, either nationally or at the state level, with confidence. Therefore, the questions we were asked cannot be answered because of either significant data gaps or methodological problems or both.

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Request Letter

NINETY-NINTH CONGRESS

Congress of the United States

House of Representatives

ENVIRONMENT, ENERGY, AND NATURAL RESOURCES
SUBCOMMITTEE
OF THE
COMMITTEE ON GOVERNMENT OPERATIONS
RAYBURN HOUSE OFFICE BUILDING, ROOM B-371-C-C
WASHINGTON, DC 20515

February 25, 1986

Honorable Charles Bowsher
Comptroller General
U.S. General Accounting Office
441 G Street, N.W.
Washington, D.C. 20548

Dear Mr. Bowsher:

The Subcommittee on Environment, Energy and Natural Resources of the Committee on Government Operations has a long-term interest in hazardous waste management and disposal. One of the issues which concerns us is whether the nation has adequate treatment and disposal capacity to deal with the increasing volume of hazardous waste being produced. The issue is complicated because of uncertainty about the soundness of the methodologies used to estimate both volume of waste and treatment and disposal capacity.

Based upon recent discussions with staff of the Program Evaluation and Methodology Division, I am requesting that GAO synthesize information which exists concerning the volume of waste expected in the future and the ability of the nation's current and planned treatment and disposal capacity to manage the expected waste. The synthesis should identify major methodological problems which may lead to misestimates of either volume or capacity. The specific questions which we would like to see answered are:

1. What is the amount, location and type of known and expected future hazardous waste?

2. What capacity currently exists and is projected for the future to manage and dispose of hazardous waste?

3. How have estimates of hazardous waste volume and management capacity changed since original enactment of the Resource Conservation and Recovery Act (October, 1976)?

4. What uncertainties and data gaps obscure the answers to the foregoing questions and what methodological problems need to be addressed in order to provide better answers?

Honorable Charles Bowsher
February 25, 1986
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The Subcommittee may request additional follow-up work based upon the findings of this synthesis.

I would very much appreciate receiving a briefing report on the synthesis work by the end of June, 1986. In the meantime, please have the GAO staff assigned to this study confer with the Subcommittee staff regarding the scope and other details of the study and provide periodic briefings on its progress. The staff contact person is Don Gray, the Staff Director, who can be reached at 225-6427. I appreciate your attention to this request.

Sincerely,

Mike

MIKE SYNAR
Chairman

MS/dg

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